

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
8 March 2001 (08.03.2001)

PCT

(10) International Publication Number  
**WO 01/15962 A1**

(51) International Patent Classification<sup>7</sup>: **B62K 1/00,**  
A61G 5/06

(21) International Application Number: PCT/US00/40770

(22) International Filing Date: 29 August 2000 (29.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
09/386,686 31 August 1999 (31.08.1999) US

(71) Applicant: DEKA PRODUCTS LIMITED PARTNER-  
SHIP [US/US]; 340 Commercial Street, Manchester, NH  
03101 (US).

(72) Inventors: KAMEN, Dean, L.; 15 Westwind Drive, Bed-  
ford, NH 03110 (US). AMBROGI, Robert, R.; 141 Arah

Street, Manchester, NH 03104 (US). DUGGAN, Robert;  
P.O. Box 444, Lakeshore Drive, Stafford, NH 03110 (US).  
FIELD, Douglas; 19 Mountain Road, Bedford, NH 03110  
(US). HEINZMANN, Richard, Kurt; P.O. Box 272,  
Francestown, NH 03043 (US).

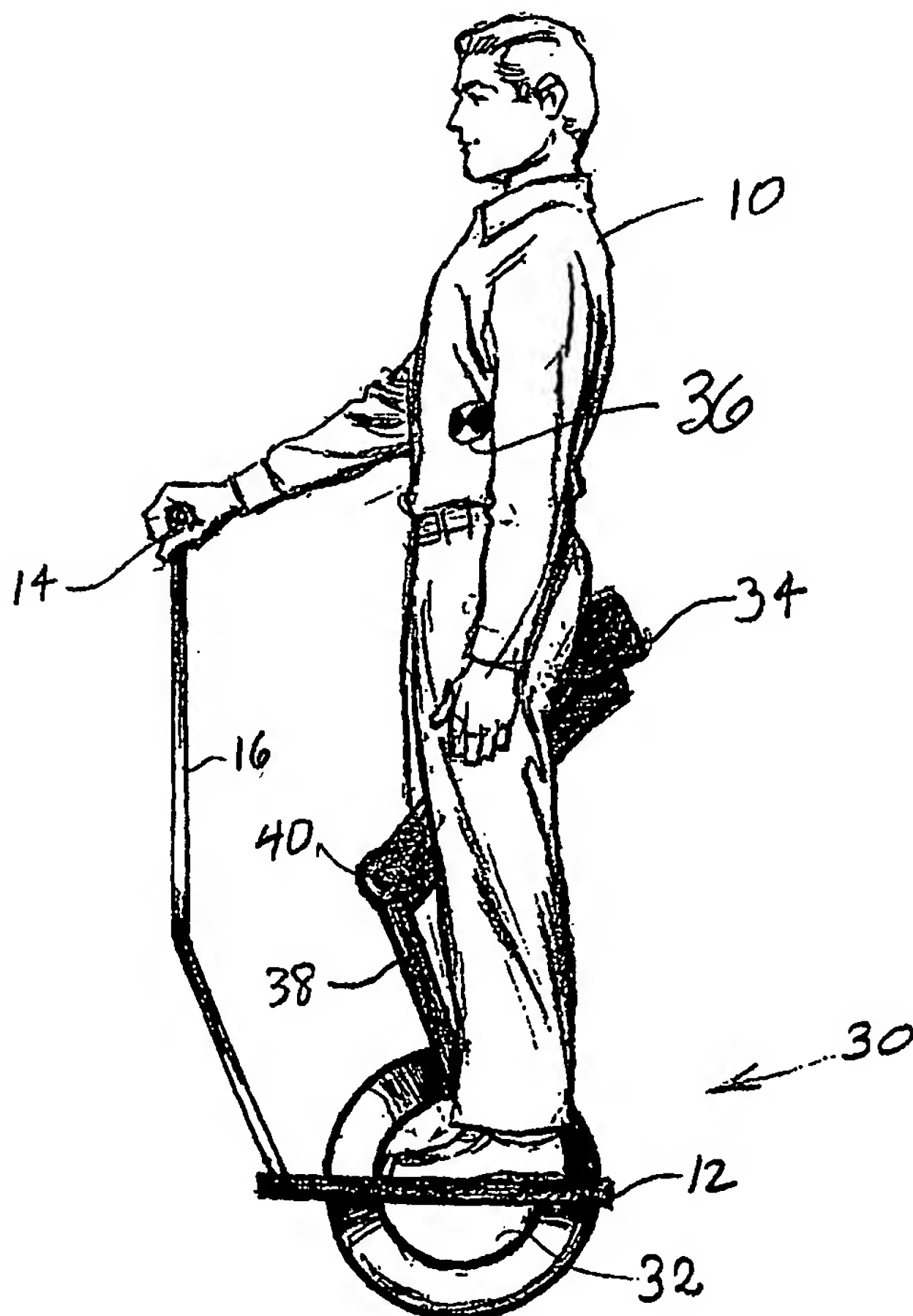
(74) Agents: SUNSTEIN, Bruce, D. et al.; Bromberg & Sun-  
stein LLP, 125 Summer Street, Boston, MA 02110-1618  
(US).

(81) Designated States (*national*): AE, AL, AM, AT, AU, AZ,  
BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK,  
DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL,  
IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU,  
LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT,  
RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA,  
UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian

[Continued on next page]

(54) Title: VEHICLE STABILIZING SYSTEM HAVING PIVOTAL SUPPORT



(57) Abstract: A balancing vehicle that supports a rider on a support such as a seat in a such a manner as to allow the position of the center of gravity of the vehicle to be varied by motion of the support. Motion of the support additionally provides for control of a drive that propels the vehicle in a manner responsive to the position of the center of gravity. The vehicle is thus capable of control by leaning of a seated rider.

WO 01/15962 A1



patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— With international search report.

— Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

## VEHICLE STABILIZING SYSTEM HAVING PIVOTAL SUPPORT

Technical Field

5           The present invention pertains to a balancing personal vehicle having a support for a human subject, the support being pivotable in order to allow the subject to be supported at a desired angle with respect to ground contacting elements of the vehicle.

Background of the Invention

10           Personal vehicles may be self-propelled and user-guidable, and, further, may entail stabilization in one or both of the fore-aft or left-right planes, such as when no more than two wheels are in ground contact at a time. Vehicles of this sort may be operated in a mode in which motion of the vehicle, including acceleration (both linear and turning), is controlled partially or entirely by leaning of the vehicle as caused by a  
15   subject riding the vehicle. Several such vehicles are described in U.S. Patent no. 5,971,091 which is incorporated herein by reference.

Such balancing vehicles may lack static stability. Referring, for example, to Fig. 1A, wherein a prior art personal transporter is shown and designated generally by numeral 18, a subject 10 stands on a support platform 12 and holds a grip 14 on a handle  
20   16 attached to the platform 12, so that the vehicle 18 of this embodiment may be operated in a manner analogous to a scooter. A control loop may be provided so that leaning of the subject results in the application of torque to wheel 20 about axle 22 thereby causing an acceleration of the vehicle. Vehicle 18, however, is statically unstable, and, absent operation of the control loop to maintain dynamic stability, subject  
25   10 will no longer be supported in a standing position and will fall from platform 12. Another prior art balancing vehicle is shown in Fig. 1B and designated generally by numeral 24. Personal vehicle 24 shares the characteristics of vehicle 12 of Fig. 1A, namely a support platform 12 for supporting subject 10 and grip 14 on handle 16 attached to platform 12, so that the vehicle 18 of this embodiment may also be operated  
30   in a manner analogous to a scooter. Fig. 2 shows that while vehicle 24 may have clusters 26 each having a plurality of wheels 28, vehicle 24 remains statically unstable and,

absent operation of a control loop to maintain dynamic stability, subject 10 will no longer be supported in a standing position and may fall from platform 12.

### Summary of the Invention

In accordance with a preferred embodiment of the invention, there is provided a  
5 device for transporting a human subject over a surface. The device has a platform defining a fore-aft plane that supports a payload including the human subject. The device also has a ground-contacting module that includes a ground-contacting member movably coupled to the platform. The platform and the ground-contacting module are components of an assembly, and the position of the center of gravity of the assembly is  
10 defined with respect to the ground-contacting member. The device also has a support for supporting the subject, where the support is coupled to the platform in such a manner as to permit variation in the fore-aft plane of the position of the center of gravity. Furthermore, the device has a drive, coupled to the ground contacting module, for delivering power to the ground-contacting module in a manner responsive to the  
15 position of the center of gravity.

In accordance with alternate embodiments of the present invention, the support includes a seat. The support may be coupled to the platform at a pivot oriented to allow motion of the support about an axis substantially transverse to the fore-aft plane. The device may have a handle, affixed to the platform, having a grip at approximately waist  
20 height of the subject, so that the device may be operated in a manner analogous to a scooter. The ground-contacting module may be characterized by a region of contact with the ground and the support may have an articulated member, biased for supporting a portion of the weight of the subject, and the support may have a region of local stability substantially above the region of contact with the ground of the ground-contacting  
25 module.

In accordance with a further embodiment of the invention, there is provided a device for carrying a user, wherein the device has a platform and a user support having a position defined with respect to the platform and coupled to the platform in such a manner that the user may vary the position of the support with respect to the platform in  
30 the course of normal operation of the device. The device also has a motorized drive that propels the platform over an underlying surface through motion of at least one ground-

contacting member and a controller, coupled to the motorized drive, for governing the operation of the motorized drive at least in response to the position of the user support.

In accordance with yet a further embodiment of the invention there is provided a device for conveying a seated user. The device has a platform for supporting a payload  
5 including the seated user, a ground-contacting module mounted to the platform that propels the platform with respect to an underlying surface, and a drive, coupled to the ground-contacting module, for delivering power to the ground-contacting module in a manner controlled solely by leaning of the user.

10 Brief Description of the Drawings

The invention will be more readily understood by reference to the following description, taken with the accompanying drawings, in which:

FIG. 1A is a side view of a prior art dynamically balancing vehicle of the type in which an embodiment of the invention may be advantageously employed;

15 FIG. 1B is a side view of a further prior art dynamically balancing vehicle of the type in which an embodiment of the invention may be advantageously employed;

FIG. 2 is a side view of a dynamically balancing vehicle having an articulated pivotable support in accordance with an embodiment of the invention;

20 FIG. 3 is a side view of the dynamically balancing vehicle of Fig. 2 showing the articulated pivotable support in a partially folded configuration; and

FIG. 4A is a side view of a dynamically balancing vehicle showing an articulated pivotable support in a further embodiment of the present invention;

FIG. 4B is a further side view of the embodiment of Fig. 4A showing two positions of the pivotable support;

25 FIG. 5A is a side view of a pivotable support having a central equilibrium position in accordance with a further embodiment of the present invention; and

FIG. 5B is a further side view of the embodiment of Fig. 5A showing detail of a cam-follower arrangement.

30 Detailed Description of Preferred Embodiments

Referring to Fig. 1A, prior art balancing vehicle 18 does not provide a seat for



the subject **10** using the vehicle. The subject stands on a platform **12** and holds a grip **14** on handle **16** attached to platform **12**, so that the vehicle of this embodiment may be operated in a manner analogous to a scooter. The pitch of the vehicle may be sensed and compensated for in the control loop, so that if the subject leans forward, the vehicle will  
5 move forward, and similarly, leaning in other directions may cause corresponding motion of the vehicle. Accordingly, a forward lean will cause forward movement; a backward lean will cause backward movement. Appropriate force transducers may be provided to sense leftward and rightward leaning and related controls provided to cause left and right turning as a result of the sensed leaning. The leaning may also be detected  
10 using proximity sensors. Similarly, the vehicle of this embodiment may be equipped with a foot- (or force-) actuated switch to activate the vehicle, in such a manner that the switch is closed so as to power the vehicle automatically when the subject stands on the platform **12**.

Referring now to Fig. 2, a personal vehicle **30** is shown of the type in which  
15 pitch of the vehicle may be sensed and compensated for by application of torque to one or more wheel **32** (or other ground-contacting members) by operation of a control loop (not shown) and wheel actuator (not shown), so that if subject **10** leans forward, the vehicle is caused to move forward. It is to be understood that platform **12** is not necessarily coupled directly to wheel **32**. Tilting of the vehicle is not necessarily  
20 canceled during ordinary operation of the vehicle, so that sustained motion and sustained acceleration may be achieved. In accordance with an embodiment of the present invention, a seat **34** is provided for supporting a portion of the weight of subject **10**. Subject **10** may still vary the position of his center of gravity, and the position of the center of gravity **36** of the combination of vehicle **30** and subject **10** while seat **34**  
25 continues to support a portion of the weight of the subject by virtue of the pivotability of seat **34** with respect to platform **12**.

It is to be understood that within the scope of the present invention, as described herein and as claimed in any appended claims, wheel **32** may rotate about a single axle, or, alternatively, about an axis that may vary in orientation, in the manner of a uniball.

30       Seat **34** may be coupled to platform **12** by any of a variety of mechanisms. In accordance with a preferred embodiment of the present invention, seat **34** is coupled to

platform **12** via link **38**, itself pivotally coupled to platform **12**, and coupled to seat **34** at knee joint **40**. The articulated support comprising seat **34** and link **38** may be biased by a spring arrangement (not shown) or its equivalent so as to counter the weight of the subject. Figure 3 shows seat **34** depressed at knee joint **40** with respect to link **38**.

5 Additionally, pivot **42** is shown coupling link **38** to support platform **12** in a manner as to constrain link **38** to fore-aft motion about an axis substantially transverse to the fore-aft plane. The spring arrangement (not shown) may include any means, such as a coil spring or a gas spring, known for biasing the support mechanism for supporting some fraction of the weight of the subject. Additionally, mechanisms known in the art for  
10 providing for translation of seat **34** in a fore-aft direction for shifting the weight of subject **10** with respect to ground-contacting member **32** are within the scope of the present invention.

An alternative to the articulating folding seat of the embodiment of Fig. 3 is described with reference to Fig. 4A. A balancing personal vehicle **44** is shown in which  
15 seat **34** may be pivoted with respect to support platform **12** by means of a seat support mechanism designated generally by numeral **46**. Seat support **46** has two substantially linear members **48** which pivot in about pivots **50** through which linear members **48** are coupled to platform **12**. Linear members **48** are coupled to seat **34** at pivots **52**. A subject seated on seat **34** may shift her weight, and thereby the center of gravity of the  
20 combination of vehicle and subject, by moving seat **34** in a fore-aft direction. Fig. 4B shows the articulating folding seat of Fig. 4A in two positions: the position designated **54** places the center of gravity of the vehicle, including the rider, substantially above the region of contact of the ground-contacting member **20** (shown in Fig. 4A) with the ground. Seat **34** may also be folded up toward handle **16** as in the position designated by  
25 numeral **56**. In the embodiment shown in Figs. 4A and 4B, seat **34** is highest, and thus possesses the greatest potential energy, in central position **54**.

Referring now to Fig. 5A, in accordance with other embodiments of the present invention, stability is provided by ensuring that the central position of the seated user, substantially above axle **22**, is a stable position, i.e., a position characterized by a local  
30 minimum of potential energy. Thus, with respect to the central position designated by numeral **54**, seat **34** is displaced further from platform **12**, and thus higher above level

ground, as seat 34 is moved by virtue of the rider moving in either a forward direction 60 or an aft direction 62. In accordance with the embodiment depicted in Fig. 5A, seat 34 is supported by a substantially trilateral arrangement 64 of links. Arm 66 pivots about a pivot point 68 fixed with respect to platform 12, while link 70 couples arm 66 to seat 34. Link 72, substantially parallel to link 70, supports seat 34 in a substantially horizontal orientation in its central position 54. The third side of trilateral arrangement 64 is formed by link 74. Link 74, as shown in greater detail in Fig. 5B, may be a rigid member or a suspension member, as shown, containing a gas spring 76 which serves to cushion seat 34 with respect to vibration transmitted from the road surface through platform 12. Link 74 is coupled to cam follower 78 which rides on cam surface 80 in such a manner as to provide a well 82 of stability at the center of motion of seat 34. If seat 34 moves fore or aft, cam follower 78 is driven up cam 80, thereby increasing the height of seat 34 relative to platform 12 relative to its position of stability at the center. This reduces the effort required of the rider to maintain a centered body position, thereby advantageously allowing the rider to maintain a more relaxed position and momentarily to remove his/her hands from the handlebar.

It is to be understood that other mechanical configurations providing for seat 34 to rise as seat 34 is moved either forward or aft of its central position 54 wherein the center of gravity of the vehicle and rider is substantially over the region of contact of the vehicle with the ground are within the scope of the present invention as claimed in the appended claims.

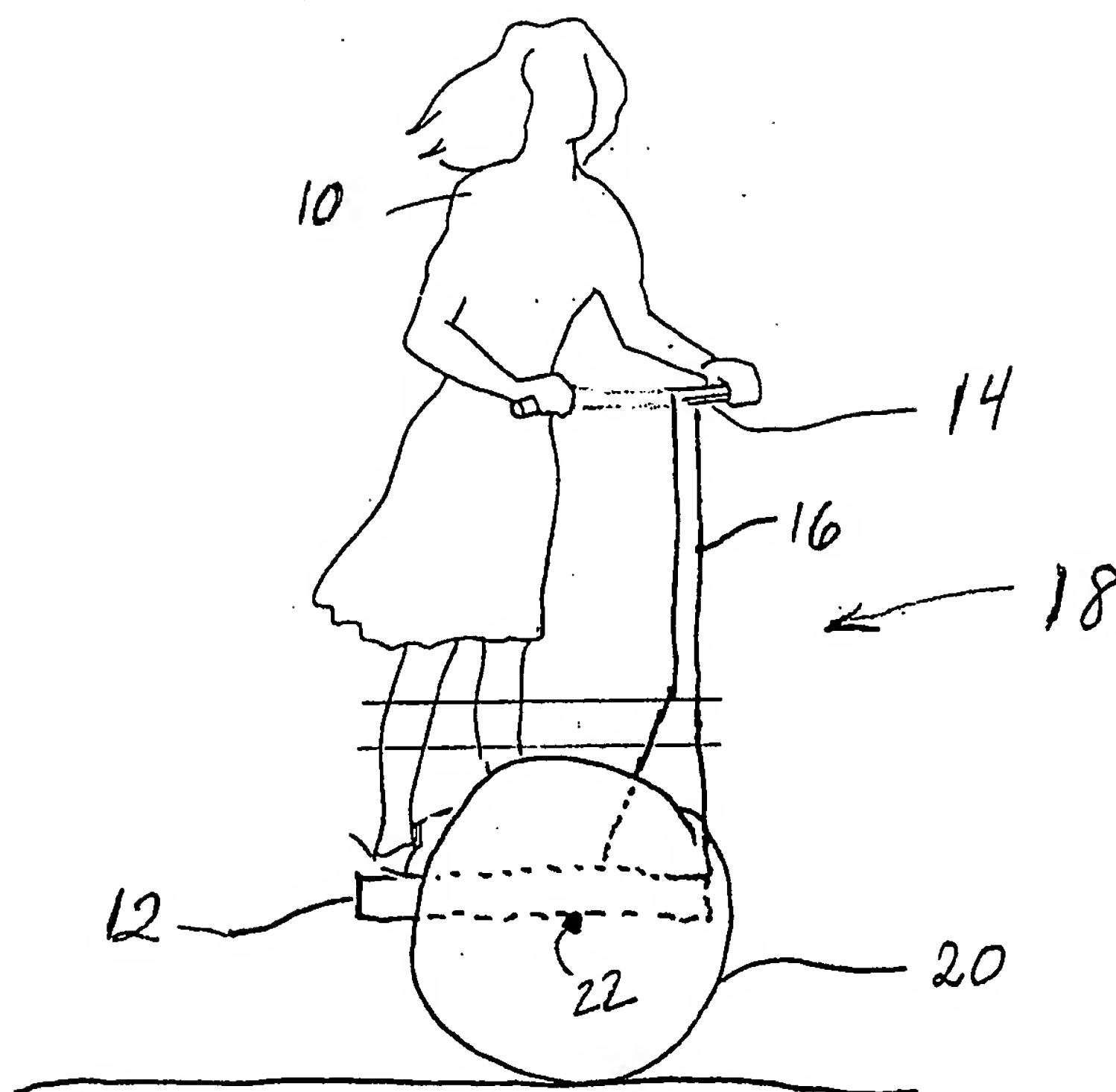
The described embodiments of the invention are intended to be merely exemplary and numerous variations and modifications will be apparent to those skilled in the art. All such variations and modifications are intended to be within the scope of the present invention as defined in the appended claims.



## WE CLAIM:

1. A device for transporting a human subject over a surface, the device comprising:
  - a. a platform defining a fore-aft plane, the platform supporting a payload including the human subject;
  - 5 b. a ground-contacting module, including a ground-contacting member movably coupled to the platform, the platform and the ground-contacting module being components of an assembly having a center of gravity, the center of gravity having a position defined with respect to the ground-contacting member;
  - 10 c. a support for supporting the subject, the support coupled to the platform in such as manner as to permit variation of the position of the center of gravity in the fore-aft plane by motion of the support; and
  - d. a drive, coupled to the ground-contacting module, for delivering power to the ground-contacting module in a manner responsive to the position  
15 of the center of gravity.
2. A device in accordance with claim 1, wherein the support includes a seat.
3. A device according to claim 1, wherein the support is coupled to the platform at a pivot oriented to allow motion of the support about an axis substantially transverse to the fore-aft plane.
- 20 4. A device according to claim 1, further comprising a handle, affixed to the platform, having a grip at approximately waist height of the subject, so that the device may be operated in a manner analogous to a scooter.
5. A device according to claim 1, wherein the support includes an articulated member, biased for supporting a portion of the weight of the subject.
- 25 6. A device according to claim 1, wherein the ground-contacting module is characterized by a region of contact with the ground, and wherein the support has a position of local stability substantially above the region of contact with the ground of the ground-contacting module.
7. A device for carrying a user, the device comprising:
  - 30 a. a platform;
  - b. a user support having a position defined with respect to the platform and

- coupled to the platform in such a manner that the user may vary the position of the support with respect to the platform in the course of normal operation of the device;
- 5           c.     a motorized drive that propels the platform over an underlying surface through motion of at least one ground-contacting member; and
- d.     a controller, coupled to the motorized drive, for governing the operation of the motorized drive at least in response to the position of the user support.
8.     A device according to claim 7, wherein the position of the support with respect to the platform may be varied by leaning of the user.
- 10     9.     A device for conveying a seated user, the device comprising:
- a.     a platform for supporting a payload including the seated user;
- b.     a ground-contacting module mounted to the platform that propels the platform with respect to an underlying surface;
- 15     c.     a drive, coupled to the ground-contacting module, for delivering power to the ground-contacting module in a manner controlled solely by leaning of the user.



PRIOR ART

FIG 1A

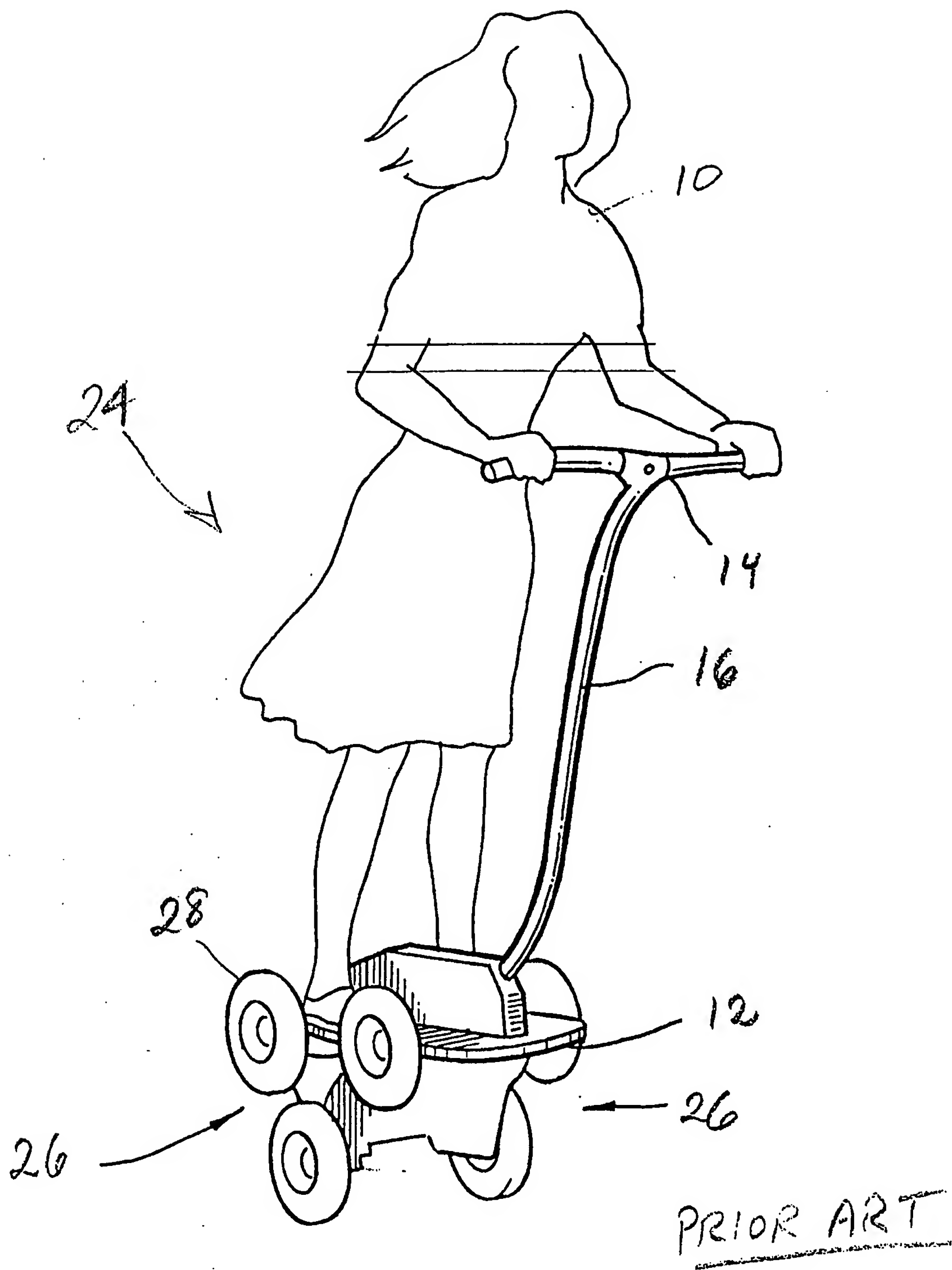


Fig. 1B

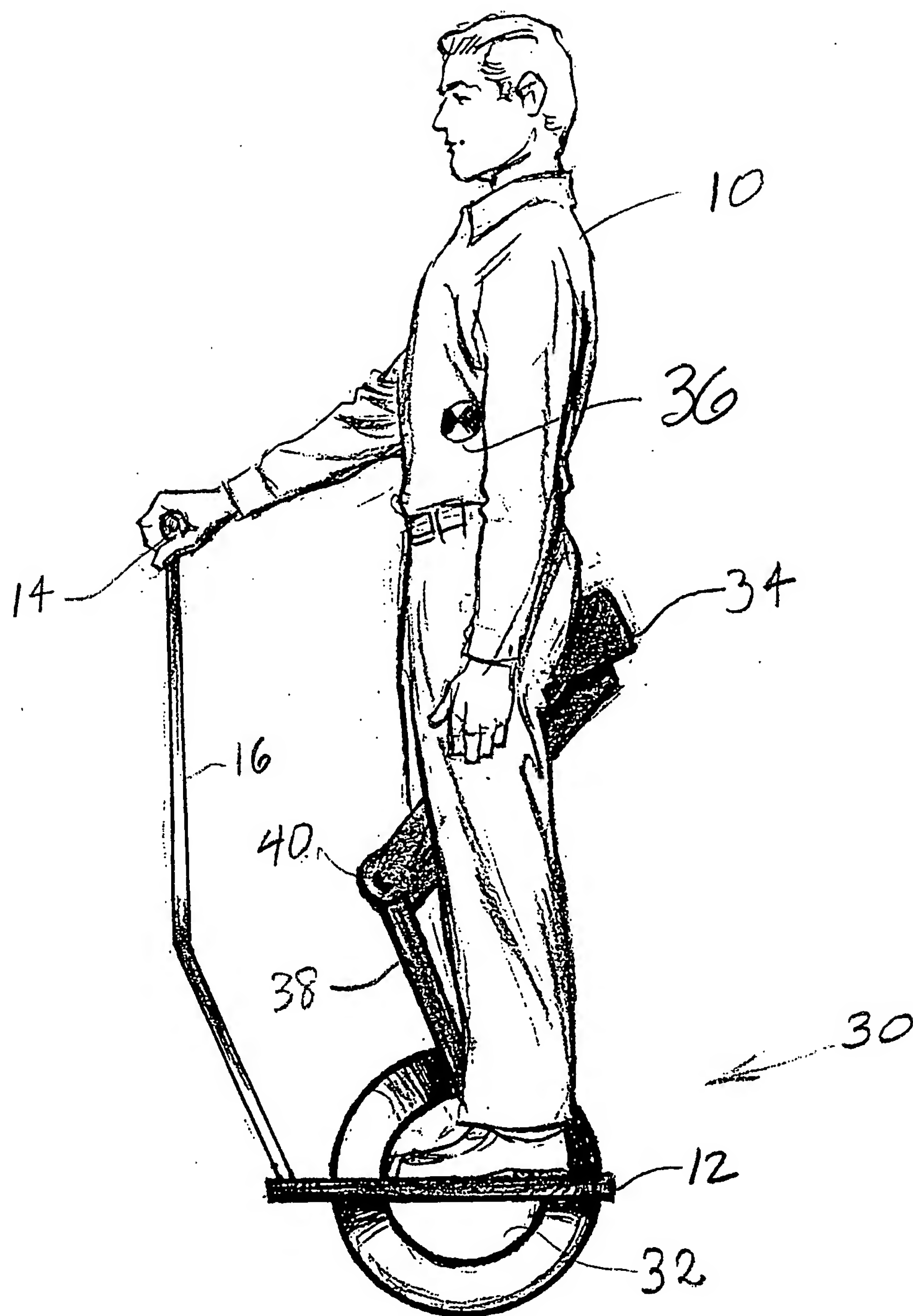


Fig 2



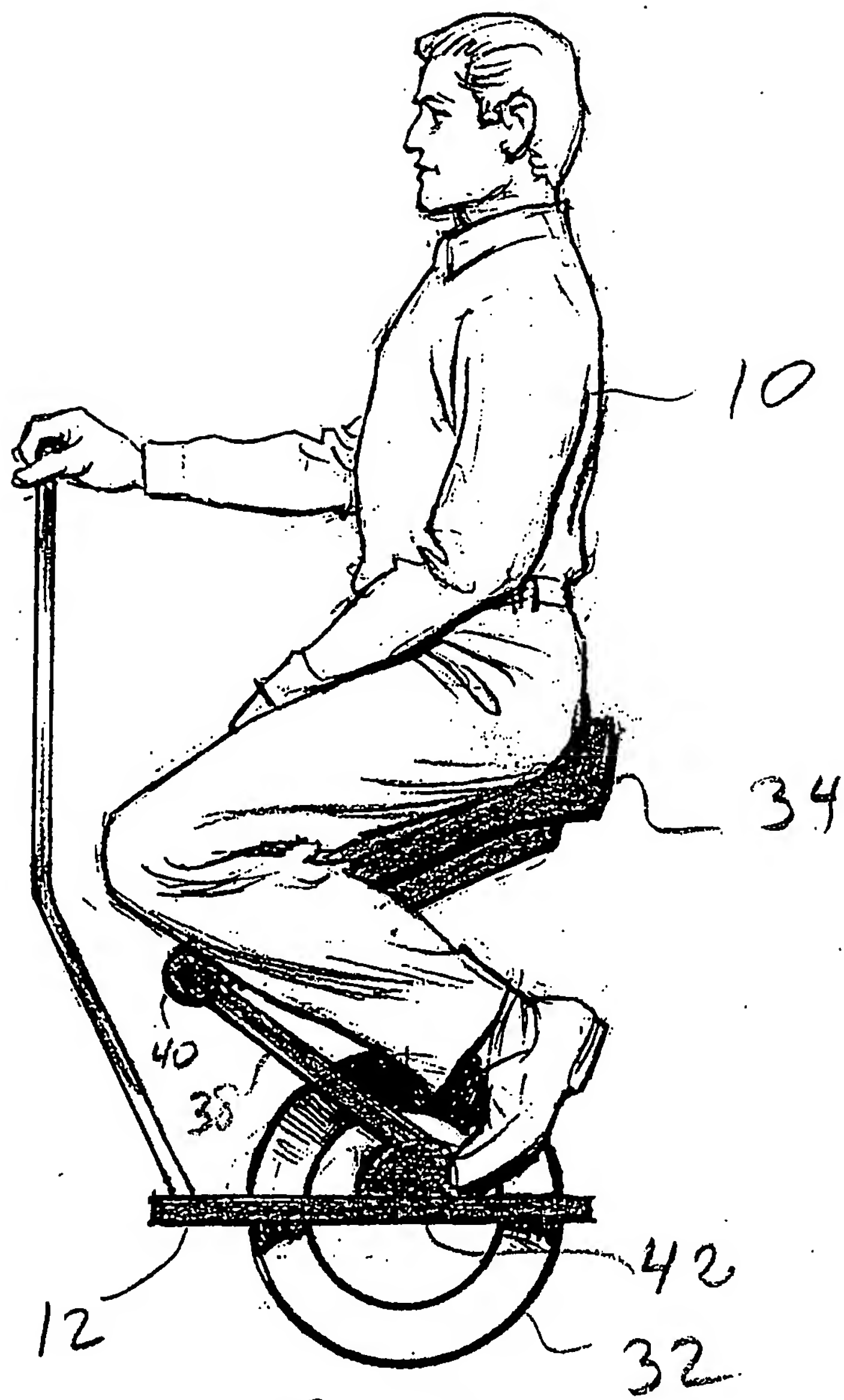


Fig 3

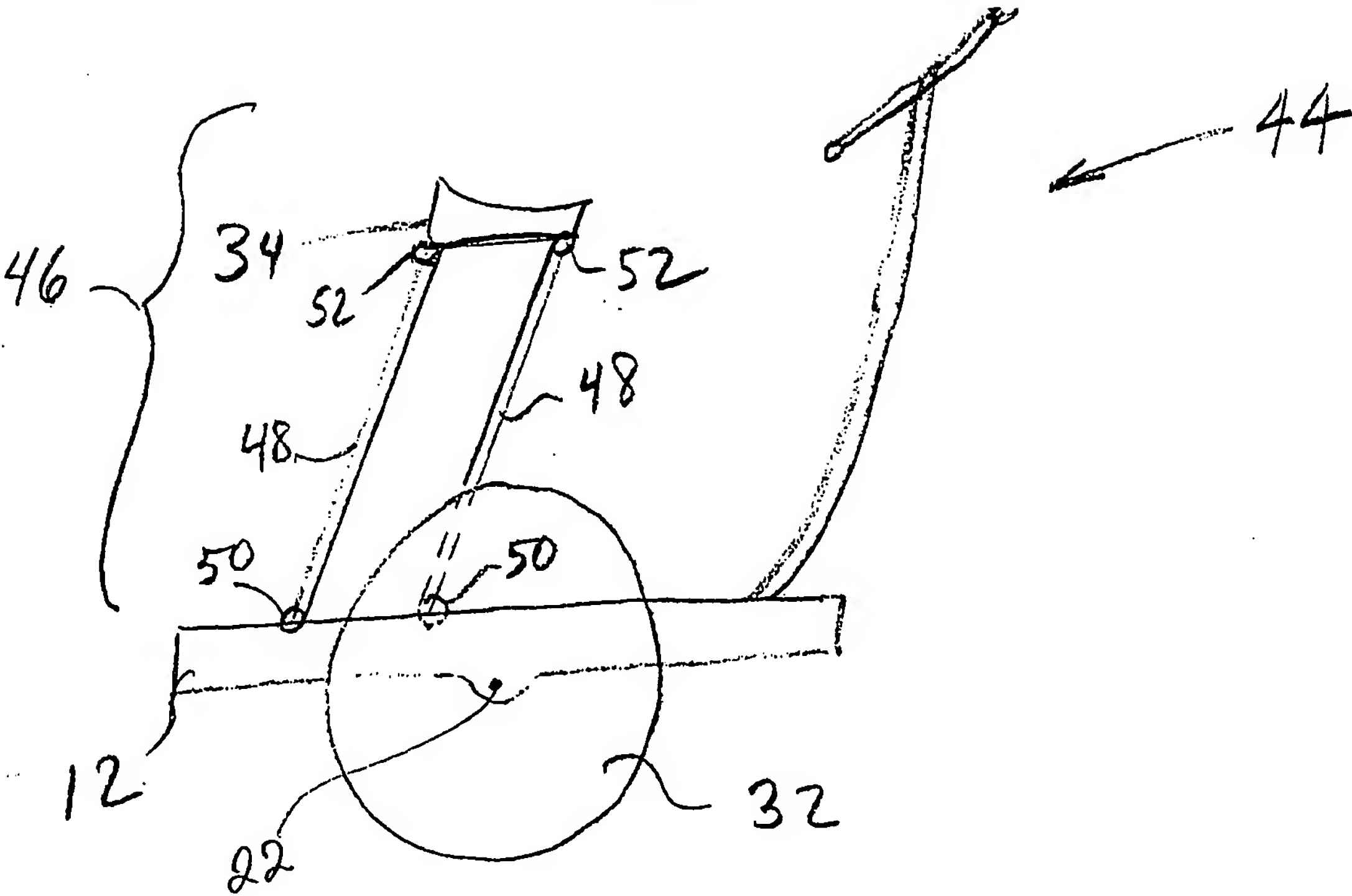


Fig. 4A

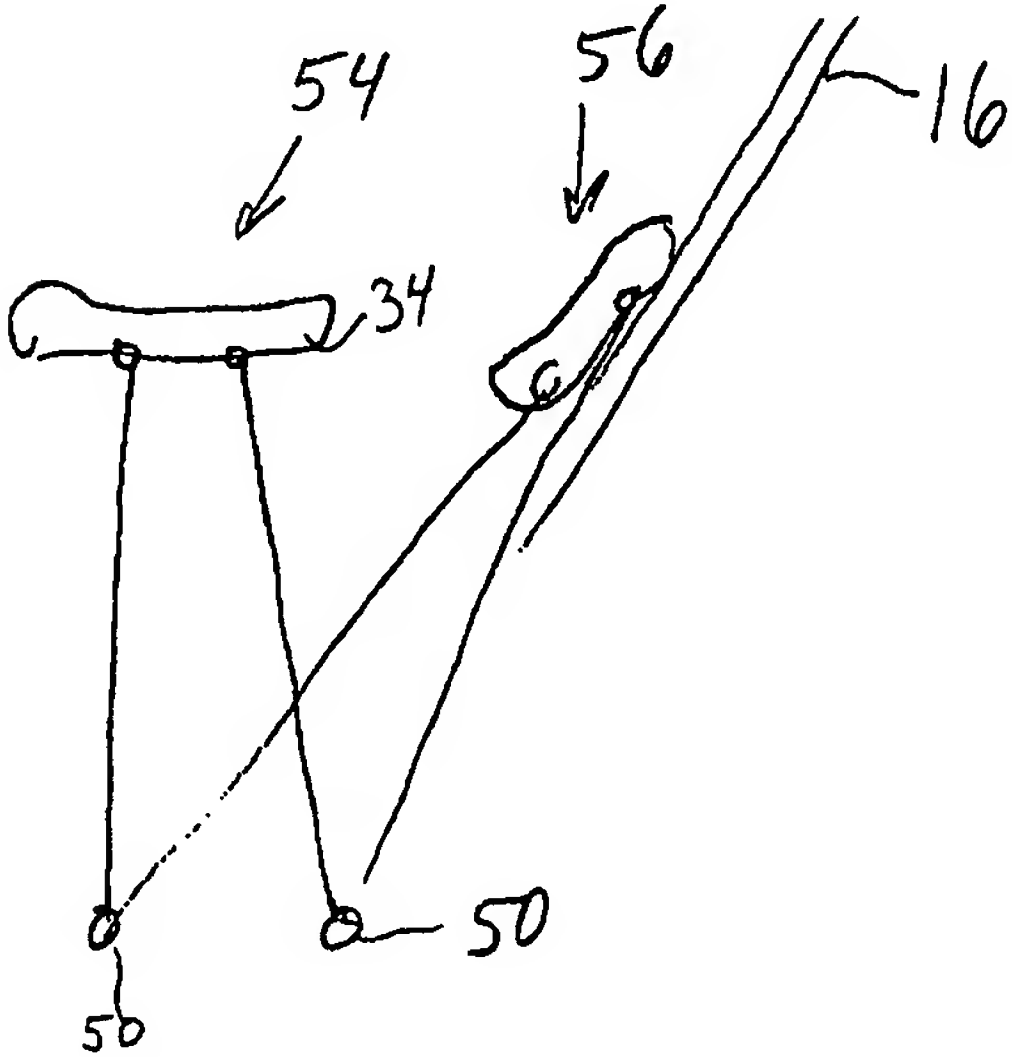


Fig. 4B

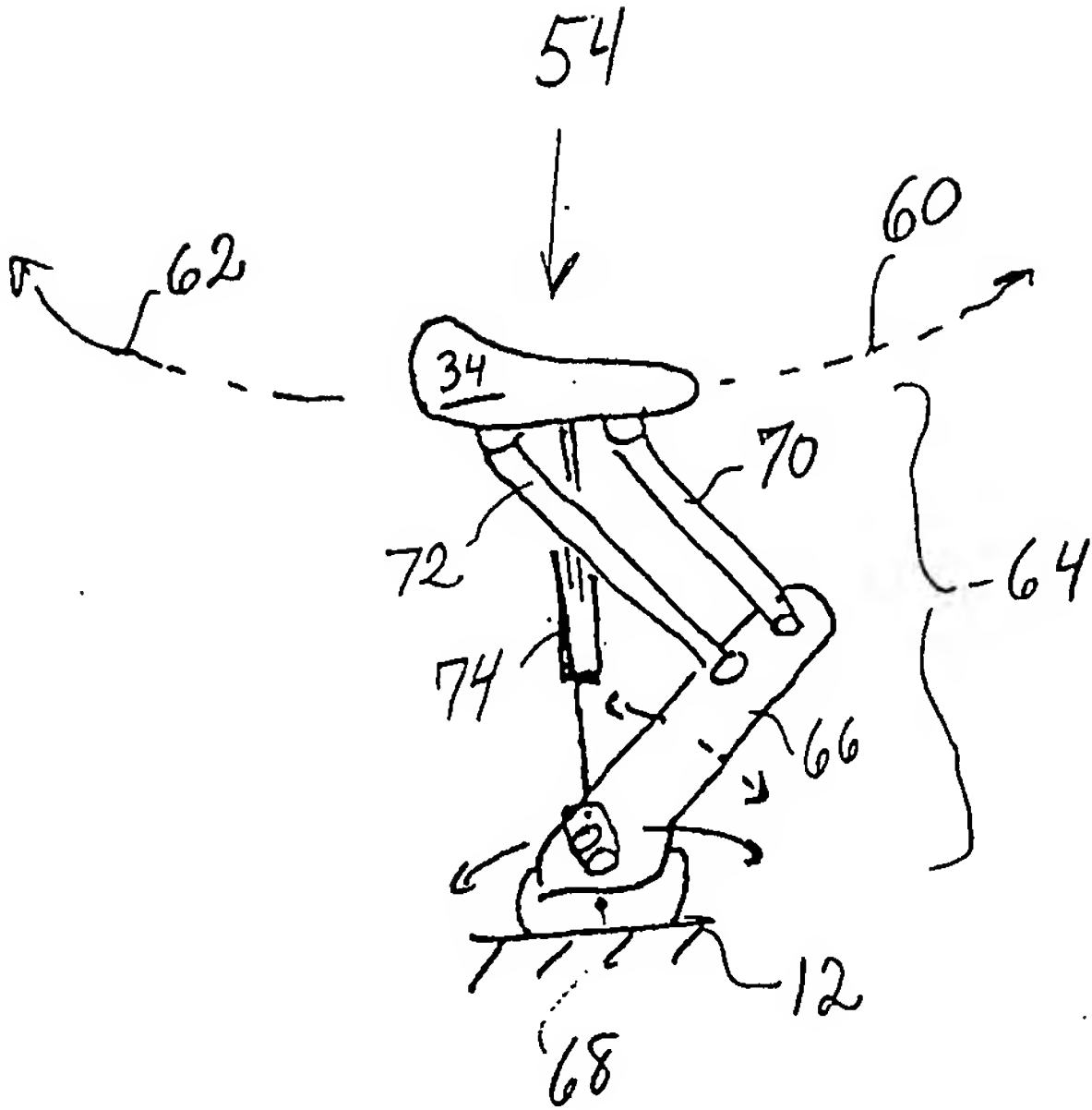


Fig. 5A

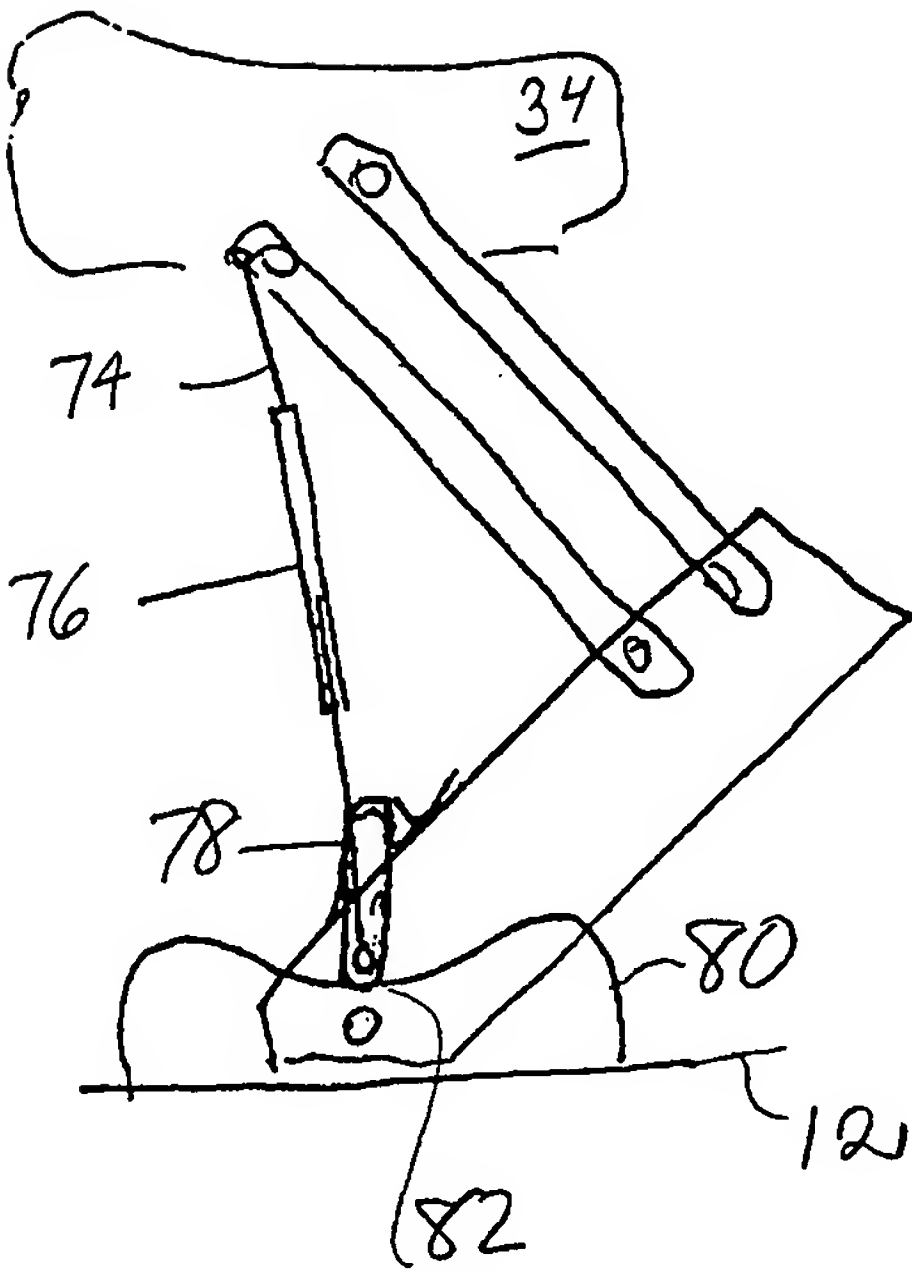


Fig. 5B

# INTERNATIONAL SEARCH REPORT

Intern al Application No  
PCT/US 00/40770

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 B62K1/00 A61G5/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 B62K A61G B62M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 23478 A (DEKA) 8 August 1996 (1996-08-08) figure 24 ---	1,7,9
X	US 4 241 931 A (HEALY) 30 December 1980 (1980-12-30) the whole document ---	1,7,9
A	DE 38 00 476 A (ANSCHÜTZ & CO) 20 July 1989 (1989-07-20) the whole document -----	1,7,9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*8\* document member of the same patent family

Date of the actual completion of the international search

28 December 2000

Date of mailing of the international search report

05/01/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.  
Fax: (+31-70) 340-3016

Authorized officer

Denicolai, G

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/40770

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9623478 A	08-08-1996	AU 705704 B	27-05-1999
		AU 1912395 A	21-08-1996
		AU 4473999 A	28-10-1999
		AU 4474099 A	28-10-1999
		AU 4474199 A	28-10-1999
		AU 4474299 A	28-10-1999
		EP 0806929 A	19-11-1997
		FI 973197 A	01-08-1997
		JP 11500331 T	12-01-1999
		NO 973153 A	09-09-1997
		NZ 282114 A	26-06-1998
-----			
US 4241931 A	30-12-1980	NONE	
-----			
DE 3800476 A	20-07-1989	WO 8906117 A	13-07-1989
		EP 0378588 A	25-07-1990
-----			